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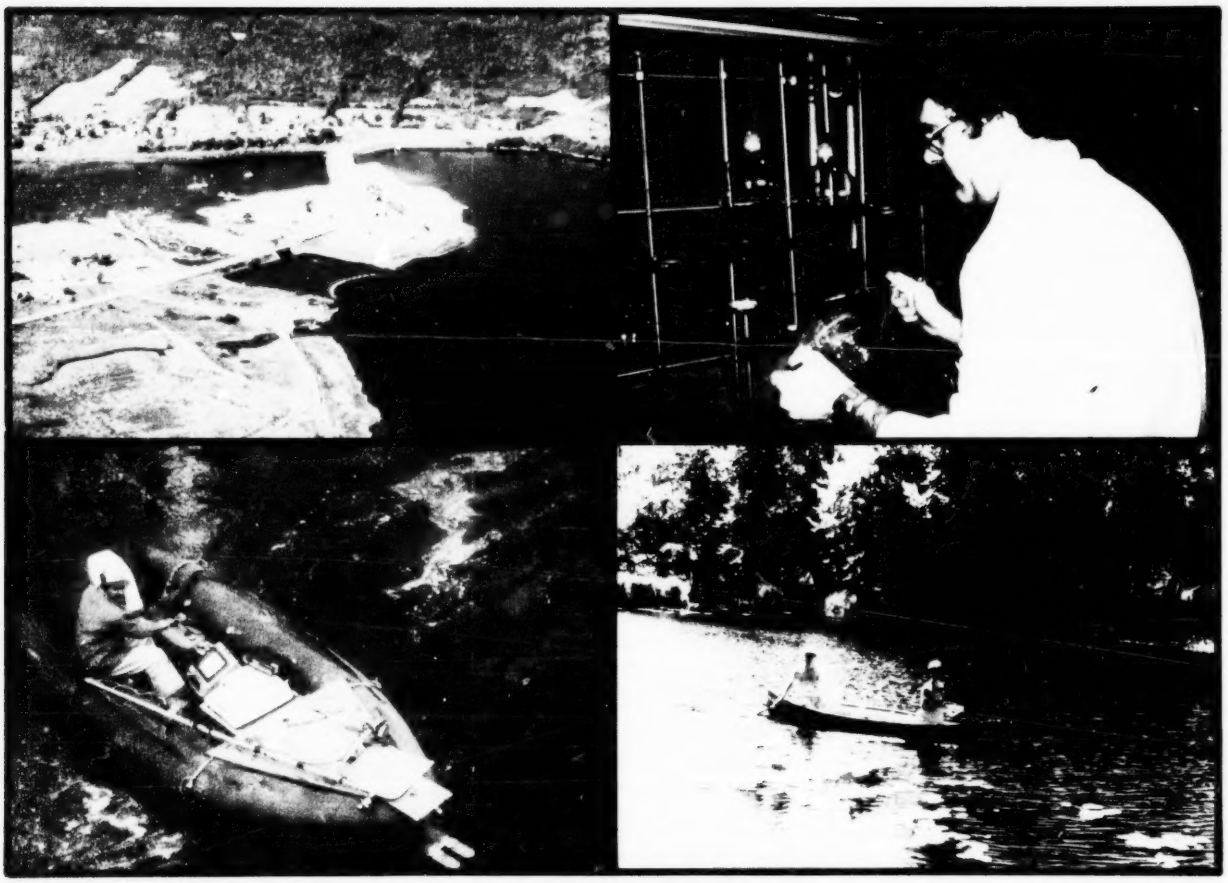

Canada

INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER RESOURCES BRANCH
DARTMOUTH , NOVA SCOTIA

HYDROMETRIC STATION REVIEW

NORTH LITTLE RIVER

NOVA SCOTIA

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ABSTRACT

Streamflow data have been collected at the hydrometric gauging station site, North Little River below Beaver Dam Lake, from 1969 to the present. This station is operated as part of the ongoing Water Resources Branch National Water Surveys Program at the request of the Province of Nova Scotia and is totally funded by the Province. This report is a hydrometric station review of the North Little River for the purpose of providing the Canada-Nova Scotia Agreement Coordinators with recommendations on the future management of this station and why. The collected flow data are presented in various tabular, graphical and statistical ways. This report also contains a section on the history of the North Little River gauging station.

The analyses and interpretations of the streamflow data show that estimates of mean characteristics of the flow regime can be improved only slightly. Furthermore, for most engineering needs streamflow data with sufficient accuracy can be estimated from nearby gauged streams. Therefore, it is being recommended that the North Little River hydrometric station be discontinued effective 31 March, 1988.

Résumé

Des données hydrométriques ont été collectionnées au site North Little River sous Beaver Dam Lake depuis 1969 jusqu'au présent. Cette station fait partie du programme national des relevés hydrométriques de la branche des ressources en eau suite à la demande de la province de la Nouvelle-Écosse, qui en défrait tous les coûts. Ce rapport est une étude de la station à la North Little River dans le but de donner aux coordinateurs de l'Accord Canada-Nouvelle Ecosse des recommendations sur la gestion future de cette station. Les débits collectionnés sont présentés sous diverses formes tabulaires, graphiques et statistiques. Ce report contient aussi une section sur l'histoire de la jauge sur la North Little River.

Les analyses et les interprétations des données de débits indiquent que les estimations des charactéristiques du débit moyen ne peuvent être améliorées que marginalement. De plus, pour la plupart des besoins en génie, des données de débit avec suffisamment d'exactitude peuvent être estimées à partir de jauges adjacentes. Par conséquent, il est recommandé que la jauge hydrométrique sur la North Little River soit discontinuée effectif le 31 mars 1988.

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HYDROMETRIC STATION REVIEW, NORTH LITTLE RIVER, NOVA SCOTIA

1.0 INTRODUCTION

1.1 Purpose of this Report

Streamflow data have been collected at the hydrometric gauging station site, North Little River below Beaver Dam Lake, from 1969 to the present. This station is operated as part of the ongoing Water Resources Branch National Water Surveys Program at the request of the Province of Nova Scotia and is totally funded by the Province. The purpose of this report is to conduct a review of the hydrometric station North Little River (01FA003) on Cape Breton Island and to produce for the Canada-Nova Scotia Agreement Coordinators recommendations on the future management of this station and why.

1.2 Scope of Report

This report reviews the hydrometric station on the North Little River to determine its usefulness to the hydrometric network. Two other stations are also included in the analytical analysis for the purpose of testing data transfer. These stations are River Inhabitants (01FA001) on Cape Breton Island and Clam Harbour River (01ER001) on mainland Nova Scotia.

A brief description of the station history of North Little River is presented in this report.

The report culminates with an overall assessment of the North Little River hydrometric station and recommendations concerning future monitoring at this site are provided.

2.0 BACKGROUND

2.1 Hydrometric Station Description

The North Little River below Beaver Dam Lake gauging station has been operated on a continuous basis since 9 October, 1969 with the exception of 1980 and 1981 when it was operated seasonally. The station consists of a float gauge (stilling well), with a frost tube, and linked to an A-35 Stevens strip chart recorder. The instrumentation is housed in a standard Water Survey of Canada (WSC) wooden shelter located on the left bank and just downstream of a CN railroad crossing. Streamflow discharge measurements during extreme high flows are taken from a foot bridge constructed for this purpose. All other flow measurements are made by wading, or through the ice, in the vicinity of the gauge.

The stage-discharge relationship for this station is said to be reasonably stable throughout the range of stage. The bed material at the control is composed of a rock, gravel and sod mixture.

The streamflow records for the North Little River have been published as regulated since 1973 the year the control structure, at the outlet of McIntyre Lake, was made operational. It should be noted that only a portion of the gauged area below Beaver Dam Lake (drainage area is 26.7 km^2) is regulated, i.e., approximately 23%.

2.2 Hydrometric Station History

The hydrometric gauge on the North Little River (01FA003) was originally requested by the Nova Scotia Water Resources Commission (NSWRC) to provide information on the hydrology of the Little River watershed. North Little River is a tributary of the Little River.

A hydrometric gauging station was commissioned on the Little River near Port Richmond (01FA002) by Montreal Engineering for the purpose of collecting preliminary flow data to build a water supply reservoir for the Point Tupper Industrial Park. The water supply reservoir could also possibly be used by the Town of Port Hawkesbury. The Little River gauging station was maintained by the WSC in cooperation with the NSWRC and in conjunction with the Town of Port Hawkesbury. The hydrometric program was started the 21 November, 1967 and the station was discontinued the 18 December, 1968 on completion of the reservoir immediately upstream. The drainage area of the Little River basin to the gauge is 41.4 km^2. The hydrometric records were classified as regulated because the streamflow was controlled during construction of the dam.The Little River station was discontinued because of gravel build-up in the control section during and after construction of the dam upstream.

As previously mentioned, the North Little River (01FA003) was needed by the NSWRC to provide data on the hydrology of the Little River basin. The NSWRC also suggested this basin as an International Hydrological Decade (IHD) bench mark station, but the basin did not meet the water quality objectives required by the IHD, i.e., due to domestic installations in the basin and due to a major highway (No. 4) passing through the watershed.

The Little River system is presented in Figure 1. McIntyre Lake, regulated since 1973, is used to supply water to Beaver Dam Lake which in turn feeds water to the Little River Reservoir. The water is pumped from the Reservoir, over the hill, to Landrie Lake which was to be used as the water supply for the Point Tupper Development. The system is no longer used for this purpose as the Point Tupper Development is on hold indefinitely. The data collected at the North Little River station were used by the Nova Scotia Department of the Environment to initially develop a rule curve for the Little River system as a water supply watershed.

As a result of the Point Tupper shutdown McIntyre Lake is now regulated to ease the flooding situation through the 2 six foot diameter culverts under Highway #104.

2.3 Hydrometric Station Regulation

The flow records of North Little River hydrometric station are published as regulated since 1973. The control structure is located at the outlet of McIntyre Lake. The drainage area to the outlet of the lake is 6.07 km^2, whereas, the drainage area to the gauge is 26.7 km^2. Therefore, the regulation only affects about 23% of the total drainage area to the gauge.

The degree of regulation, since the Point Tupper shutdown, is classified as very minor (Personal Communication, R. Porter of the Nova Scotia Department of the Environment).

2.4 Factors Concerning The North Little River Gauge

There are four factors which influence the overall value of the North Little River hydrometric gauging station and these are as follows:

1. The value of the data to the natural flow regional hydrology network;
2. The value to the users of the data of any type and at any time;
3. The degree of regulation;
4. The degree of difficulty to operate and maintain the station.

The value of the North Little River gauge to the natural flow regional hydrometric network in Nova Scotia is evaluated in the next section on data analysis.

The number of requests for the North Little River data received by the WSC are very few. Since the Point Tupper shutdown, there has been no interest in this s ation by the users. The staff of the Provincial Department of the Environment are no longer using the data (Personal Communication, R. Porter of the Nova Scotia Department of the Environment).

As mentioned previously, the North Little River records are published as regulated. But, the area affected is small (23% of the total drainage area) and the degree of regulation is very minor. The station regulation, at the present time, is insignificant. This increases the value of the station data for use in regional hydrology applications.

The operation of the gauge is both difficult and dangerous. The station is accessed off of Highway #4; followed by a walk down CN railroad tracks for about 2.5 km. To move people and equipment down this stretch of track is not very easy. There is also the danger of being hit by a train. It should also be noted that the station, at this time, needs extensive repairs to maintain a quality assurance equal to other stations in the network.

3.0 DATA ANALYSIS

3.1 Scope of the Analysis

Data analyses are conducted to quantify the value of the North Little River gauging station in the Nova Scotia hydrometric network. The method used is to compare the streamflow data of the North Little River with data of other gauged streams in the same general area. If the streams are similar enough to enable a designer to transfer data at an acceptable level of accuracy to the North Little River, the stream gauge in question becomes redundant in the network. The scope of the analysis consists of data interpretations of annual means and extremes (peak and low flows) as this type of information satisfies the need of many engineering applications.

Two methods of comparing paired stations are used in the data interpretations. The two methods are: (1) a linear regression analysis; and (2) a proration technique using the drainage area. To assess the accuracy of the results, the regression coefficient (r^2) and the standard error or percent error are used. It is generally considered in hydrology that a linear regression approximation is good if the absolute value of r^2 is greater than 0.4 (Chow, 1964). It is difficult to judge the standard error as the degree of accuracy required is ultimately user or project dependent.

3.2 Data Base

The streamflow data for 3 hydrometric stations were used in the data interpretations. These included the streamflow data for River Inhabitants (01FA001), Clam Harbour River (01ER001) and the station of interest North Little River (01FA003). Table 1 presents the drainage area, gauge location and period of record for these 3 stations.

The time series data analyzed were the annual and monthly means, annual maximum instantaneous, annual minimum daily (1 and 7-day means), daily and annual total discharges. Most of the data sets were tested for randomness, homogeneity, independence and trend using nonparametric statistical tests. The results of these tests indicate that the flow data used in the analyses conform to random, independent and homogeneous samples. This would also indicate that the influence of regulation on the time series analyses is minimal. Trend was also not found in the data sets. In addition, a seasonal homogeneity test was performed on the data sets and for statistical purposes winter/spring and summer/fall flows can be regarded as having been drawn from a single population. Seasonal data analyses were, therefore, not attempted.

It should be noted that all the data available in each time series to 1986 were used in the data analyses with the exception of the outliers (high or low) identified by the statistical package (SP) program. These outliers were removed from the linear regression analyses. Also, as the data (for the above 3 stations) have been gathered over varying periods of time a comparison of the mean annual discharge over concurrent periods and the period of record was conducted. The differences that were noted were not thought significant, hence, the entire period of record at each station was used in the data interpretations.

3.3 Data Interpretations

In Tables 2 to 4, the statistical analyses on the mean monthly and mean annual discharges are presented for the River Inhabitants, Clam Harbour and North Little Rivers, respectively. The monthly depths of flow from these tables are summarized in Figure 2. It can be seen in this figure, that the equivalent depths of monthly flow for the North Little River are less than the flow depths of the River Inhabitants and Clam Harbour Rivers the majority of the time. On an annual basis the North Little River flows are about 12 to 13 percent less, on average, than the other two streams. Figure 2 shows the North Little River runoff as being less than the other two streams from October through to May, inclusive. On the other hand, from June to September the runoff is larger than the other two streams. The influence of lake storage, on the North Little River, released during times of less precipitation is assumed to cause this.

The amount of flow in any month can be expressed as a percentage of the annual value. Figure 3 shows the relative percentages for each month for the 3 stations. April, the normal spring freshet month, has about 16% of the annual flow volume. The low flows occur during the dry weather months of June to September. Low flows also usually occur in February. It should also be noted, as seen in Figure 3, that the monthly flow distribution for the 3 stations is quite similar.

In Figures 4 to 6, the frequency plots of annual maximum instantaneous discharge are shown for the River Inhabitants, Clam Harbour and North Little Rivers, respectively. The range of the annual maximum instantaneous discharge data for the Clam Harbour River shows a four fold variation, whereas, North Little River and River Inhabitants only show a two fold variation. This information tends to show that the Clam Harbour River is more flashy than the other two streams. This can also be seen in the frequency plots. The Clam Harbour River frequency curve (Figure 5) swings upwards indicating greater peak flows between recurrence intervals than the other two streams whose curves (Figures 4 and 6) tend to flatten out. The range in the data sets is compared over the same time period (1970 to 1986) for all 3 stations.

The North Little River peak flows compare better with the River Inhabitants peak flows than they do with the Clam Harbour River flows. This can be seen when the curves are superimposed on one another (Figures 4,5 and 6).

The frequency plots of the annual 1-day mean low flows for the River Inhabitants, Clam Harbour and North Little Rivers are presented in Figures 7 to 9, respectively. In Figures 10 to 12 similar information is shown but for the annual 7-day mean low flows.

The North Little River discharges, for both the 1 and 7-day mean low flows, show a good likeness when compared with the Clam Harbour River low flows. The relationship is not as good when the North Little River low flows are compared to the River Inhabitants flows. This can be seen when the low flow curves are superimposed on one another, i.e., Figures 7 to 9 for the 1-day mean and Figures 10 to 12 for the 7-day mean low flows. It should be noted that the curves for the River Inhabitants are asymptotic to the abscissa whereas the curves for both the Clam Harbour and North Little Rivers cross the abscissa (low flows are zero) between the 20 to 50 year return periods for both the 1 and 7-day mean low flows.

The flow duration curves, based on the daily flow data for the periods of record, for the River Inhabitants, Clam Harbour and North Little Rivers are presented in Figures 13 to 15, respectively. The North Little River daily discharges, when presented in this format, show a good relationship with the Clam Harbour River duration curve. The curves when superimposed on each other show a good fit, especially on the upper 2/3 of the graphs.

As each year of successive data are gathered more of the variability is seen in the long-term data set. In theory, with long-term climatic changes being the only difference a steady state condition will be approached. When the standard error has been reduced down to the natural or sampling error enough data should have been collected. Figures 16 displays this relationship for the North Little River total annual discharge data set.

After about 17 years of record the standard error of the mean is reduced to about 5% for the annual total discharge at the North Little River station. The percentage gain by getting another year of record is less than 1%. Further data collection at this site will not substantally improve the standard error of estimate for mean annual discharge at the North Little River gauge.

The results of the regression and proration analyses are presented in Table 5. These analyses are provided to estimate flow data for the North Little River using the data from nearby streams. The mean and extreme values of the North Little River data are analyzed with the River Inhabitants and Clam Harbour River data sets.

The results of the analyses are thought to be good considering the values obtained of r^2. The values obtained of the standard error or percent error, as mentioned previously, are difficult to judge (how good is good enough) as the degree of accuracy needed is dependent upon the final use of the estimated data.

As can be seen from Table 5, the regression analyses produce better results overall, although, the proration technique gives slightly better statistics for the annual maximum instantaneous flow data. When estimating the flow data for North Little River from River Inhabitants or Clam Harbour River the station that gives the best estimates depends on the time series data being estimated.

The annual mean flow for the North Little River is best estimated using regression analysis with the River Inhabitants flow data, whereas, the annual maximum instantaneous flow is best estimated using proration with the River Inhabitants flow data. The annual 1 and 7-day mean low flow is best estimated using regression analysis with the Clam Harbour River data sets.

4.0 STATION EVALUATION AND RECOMMENDATIONS

The results of this study indicate that the available streamflow record is sufficient to define the flow regime (means and extremes) of the North Little River. In particular, the estimates of the mean characteristics of the streamflow regime can be improved only slightly. Furthermore, for most anticipated engineering needs streamflow data (means and extremes) with sufficient accuracy can be estimated from the nearby streams such as River Inhabitants and Clam Harbour River.

Other factors which affect the status of the North Little River hydrometric station are as follows:

1. The data is not presently being used in an operational or project manner by anyone;

2. The streamflow is regulated, albeit minor;

3. The operation of the gauge is both difficult and dangerous in the opinion of Water Survey of Canada staff.

Although our knowledge of how representative these data are of longer term conditions is not perfect it cannot be hydrologically or economically justified that a lengthier program would be required to address this issue. Therefore it is recommended:

because...

1. Continuation of the station would not add to the hydrologic knowledge of the region;

2. It was found that there were no visible users of the station data;

3. The data are not completely natural;

4. The station requires immediate upgrading in addition to its ongoing difficulty of operation.

that...

1. The streamflow data collection program on the North Little River cease 31 March, 1988;

2. The allocation of the funds to another site in an area which has been identified as deficient in network coverage (Environment Canada and N.S. Environment, 1985) be implemented in fiscal year 1988/89. The Provincial funding could be reallocated to begin another Provincial only station or be used in 1988/89 to begin two regional hydrology Federal/Provincial network stations.

5.0 REFERENCES

1. Chow, V.T., "Handbook of Applied Hydrology", McGraw-Hill Book Company, 1964.

2. Environment Canada and Nova Scotia Department of the Environment, "Hydrologic Network Review, Nova Scotia", Halifax, 1985.

APPENDIX A

(Tables)

HYDROMETRIC STATIONS USED IN THE ANALYSES

Station	Drainage Area (km^2)	Gauge Location	Period of Record	Remarks
River Inhabitants (01FA001)	193	LAT 45 43 15 N LONG 61 17 10 W	1965 - 86	1, NAT
Clam Harbour River (01ER001)	45.1	LAT 45 28 06 N LONG 61 27 36 W	1957 - 86	1, NAT
North Little River (01FA003)	26.7	LAT 45 37 50 N LONG 61 17 05 W	1969 - 86	REG 73

Note under remarks: 1 - Water Quality Data Available
NAT - Natural Flow
REG - Regulated since 19..
(Year Shown if Known).

TABLE 1

<< STATISTICAL ANALYSIS >>

MEAN MONTHLY AND MEAN ANNUAL DISCHARGES FOR THE PERIOD - 1965 TO 1986
STATION - 01FA001 RIVER INHABITANTS AT GLENORA DRAINAGE AREA = 193 km^2

PERIOD	DISCHARGE (m^3/s) MAXIMUM	MINIMUM	MEAN	<< STATISTICS ON THE MEAN >> STANDARD DEVIATION	STANDARD ERROR	S.E. AS % OF MEAN	COEF. OF VARIATION	COEF. OF SKEW	COEF. OF KURTOSIS	RUNOFF (mm)
JAN	16.8	2.120	7.775	3.9115	0.8536	10.978	0.5031	0.4936	3.2989	108
FEB	10.8	1.390	5.813	3.1632	0.6903	11.875	0.5442	0.2291	2.2710	73
MAR	20.4	2.810	8.766	3.9818	0.8689	9.912	0.4542	1.2059	6.0714	122
APR	25.1	5.990	13.484	5.3266	1.1624	8.620	0.3950	0.5902	3.0210	181
MAY	31.2	3.210	9.275	6.2492	1.3637	14.703	0.6738	2.4864	10.8606	129
JUN	11.4	1.720	4.281	2.4249	0.5291	12.361	0.5664	1.7101	6.7061	57
JUL	7.5	0.902	2.510	1.6806	0.3667	14.612	0.6696	1.5839	6.2930	35
AUG	8.8	0.526	3.122	2.5248	0.5509	17.647	0.8087	1.1465	3.5739	43
SEP	9.4	0.666	3.364	2.1482	0.4688	13.935	0.6386	1.2226	5.1994	45
OCT	10.3	1.560	5.840	2.8057	0.5982	10.242	0.4804	-0.1255	2.5357	81
NOV	22.2	2.070	10.238	4.7744	1.0179	9.942	0.4663	0.8755	4.6005	137
DEC	15.9	3.880	10.520	3.8728	0.8257	7.849	0.3681	-0.1194	2.1729	146
ANNUAL	10.4	5.650	7.119	1.0717	0.2339	3.285	0.1505	1.2977	6.8342	1164

TABLE 2

<< STATISTICAL ANALYSIS >>

MEAN MONTHLY AND MEAN ANNUAL DISCHARGES FOR THE PERIOD - 1958 TO 1986
STATION - 01ER001 CLAM HARBOUR RIVER NEAR BIRCHTOWN DRAINAGE AREA = 45.1 km^2

		DISCHARGE (m^3/s)		<< STATISTICS ON THE MEAN >>						
PERIOD	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	STANDARD ERROR	S.E. AS % OF MEAN	COEF. OF VARIATION	COEF. OF SKEW	COEF. OF KURTOSIS	RUNOFF (mm)
JAN	3.8	0.341	1.854	1.0372	0.1926	10.391	0.5596	0.6482	2.4497	110
FEB	3.6	0.165	1.323	0.8128	0.1509	11.413	0.6146	0.9077	4.0739	72
MAR	4.4	0.575	2.016	0.9714	0.1836	9.106	0.4819	0.9031	3.7738	120
APR	6.5	1.210	3.342	1.3211	0.2497	7.470	0.3953	0.6707	3.1510	192
MAY	7.9	0.457	2.104	1.7239	0.3258	15.484	0.8193	2.0730	7.6808	125
JUN	2.6	0.141	0.916	0.6179	0.1168	12.746	0.6744	1.4494	5.3285	53
JUL	1.6	0.006	0.453	0.4335	0.0819	18.087	0.9571	1.5556	4.9084	27
AUG	2.0	0.002	0.642	0.5366	0.1014	15.796	0.8359	0.5671	2.8114	38
SEP	1.7	0.010	0.633	0.5039	0.0952	15.054	0.7966	0.5941	2.5184	36
OCT	2.8	0.230	1.320	0.7651	0.1421	10.767	0.5798	0.2315	2.2478	78
NOV	7.7	0.534	2.584	1.4493	0.2691	10.414	0.5608	1.5863	7.7717	149
DEC	5.2	0.736	2.436	1.0551	0.1959	8.042	0.4331	0.5652	3.6036	145
ANNUAL	2.3	1.080	1.636	0.2977	0.0563	3.438	0.1819	0.2028	3.3127	1145

TABLE 3

<< S T A T I S T I C A L A N A L Y S I S >>

MEAN MONTHLY AND MEAN ANNUAL DISCHARGES FOR THE PERIOD - 1969 TO 1986
STATION - 01FA003 NORTH LITTLE RIVER BELOW BEAVER DAM LAKE DRAINAGE AREA = 26.7 km^2

	DISCHARGE (m^3/s)			<< STATISTICS ON THE MEAN >>						
PERIOD	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	STANDARD ERROR	S.E. AS % OF MEAN	COEF. OF VARIATION	COEF. OF SKEW	COEF. OF KURTOSIS	RUNOFF (mm)
JAN	2.2	0.254	1.052	0.5398	0.1349	12.834	0.5134	0.5514	3.8503	105
FEB	1.5	0.124	0.708	0.3788	0.0947	13.371	0.5349	0.5234	3.5229	65
MAR	2.8	0.234	1.036	0.5526	0.1381	13.340	0.5336	2.2631	11.1229	104
APR	3.3	0.583	1.782	0.7231	0.1754	9.844	0.4059	0.4494	3.4508	173
MAY	2.3	0.299	0.915	0.4822	0.1206	13.179	0.5272	1.5398	6.7276	92
JUN	1.7	0.160	0.601	0.4140	0.1035	17.213	0.6885	1.8631	7.0892	58
JUL	1.0	0.002	0.385	0.2979	0.0745	19.316	0.7726	0.6138	2.8756	39
AUG	1.1	0.004	0.417	0.3311	0.0803	19.251	0.7938	0.6147	3.1988	42
SEP	1.1	0.004	0.470	0.3205	0.0777	16.552	0.6825	0.3774	2.8777	46
OCT	1.4	0.083	0.763	0.4605	0.1117	14.644	0.6038	-0.0765	2.1383	77
NOV	4.1	0.262	1.333	0.8338	0.1965	14.743	0.6255	2.2150	10.2005	129
DEC	2.2	0.448	1.195	0.5242	0.1236	10.342	0.4388	0.4537	2.9576	120
ANNUAL	1.2	0.691	0.862	0.1289	0.0333	3.860	0.1495	1.0518	5.6352	1019

TABLE 4

TABLE 5

SUMMARY OF THE LINEAR REGRESSION ANALYSIS VERSUS A SIMPLE PRORATION TECHNIQUE

REGRESSION ANALYSIS

Paired Station	Annual Mean Flow		Annual Maximum Instantaneous Flow		Annual 1-day Mean Low Flow		Annual 7-day Mean Low Flow	
	Regression Coefficient (r^2)	Standard Error (%)	Regression Coefficient (r^2)	Standard Error (%)	Regression Coefficient (r^2)	Standard Error (%)	Regression Coefficient (r^2)	Standard Error (%)
North Little R. vs. Clam Harbour R.	0.299	10	0.137	22	0.536	56	0.748	47
North Little R. vs. River Inhabitants	0.894	5	0.132	21	0.433	62	0.645	56

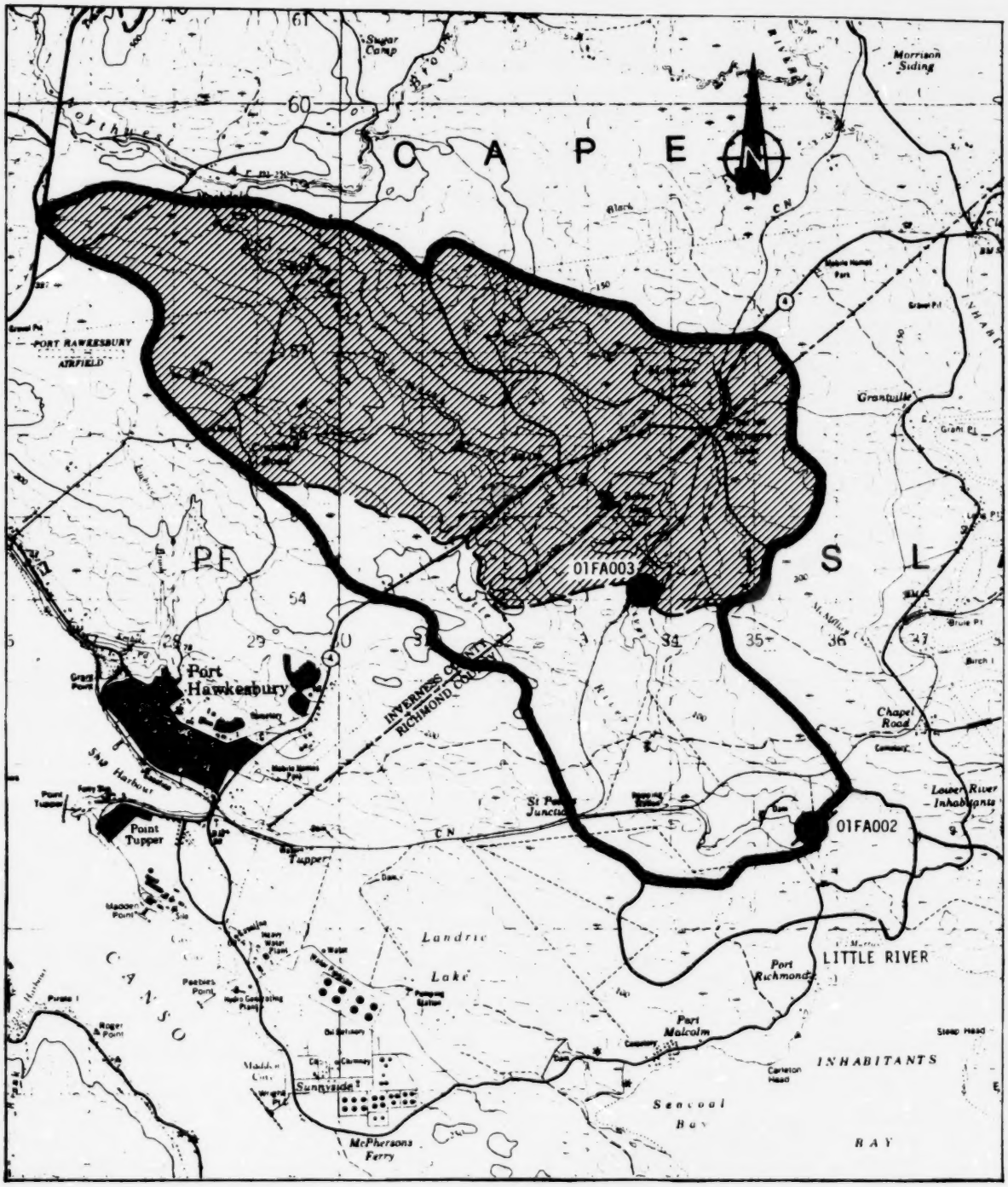
PRORATION TECHNIQUE

Paired Station	Annual Mean Flow	Annual Maximum Instantaneous Flow	Annual 1-day Mean Low Flow	Annual 7-day Mean Low Flow
	Average Percent Error Estimated vs. Recorded	Average Percent Error Estimated vs. Recorded	Average Percent Error Estimated vs. Recorded	Average Percent Error Estimated vs. Recorded
North Little R. Estimate using Clam Harbour R.	16	310	111	19
North Little R. Estimate using River Inhabitants	14	26	607	210

Note: 1) North Little River is the dependent station in the linear regressions.
2) Outliers (high or low) identified by the statistical package (SP) were removed from the linear regressions.
3) Proration Technique uses the drainage area ratio.

APPENDIX B

(Figures)



LITTLE RIVER (01FA002) AND NORTH LITTLE RIVER (01FA003) WATERSHEDS

Scale

FIGURE 1

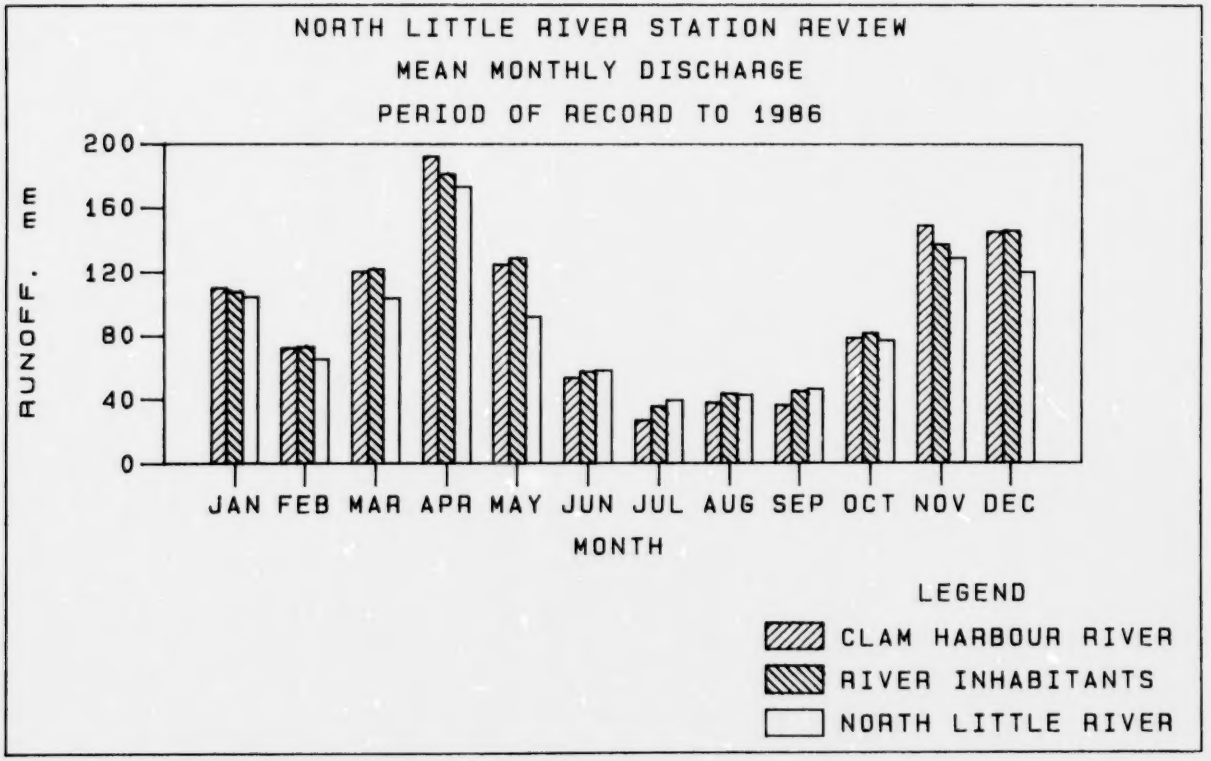

NORTH LITTLE RIVER STATION REVIEW
MEAN MONTHLY DISCHARGE
PERIOD OF RECORD TO 1986
RUNOFF, mm
200
160
120
80
40
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH
LEGEND
CLAM HARBOUR RIVER
RIVER INHABITANTS
NORTH LITTLE RIVER

FIGURE 2

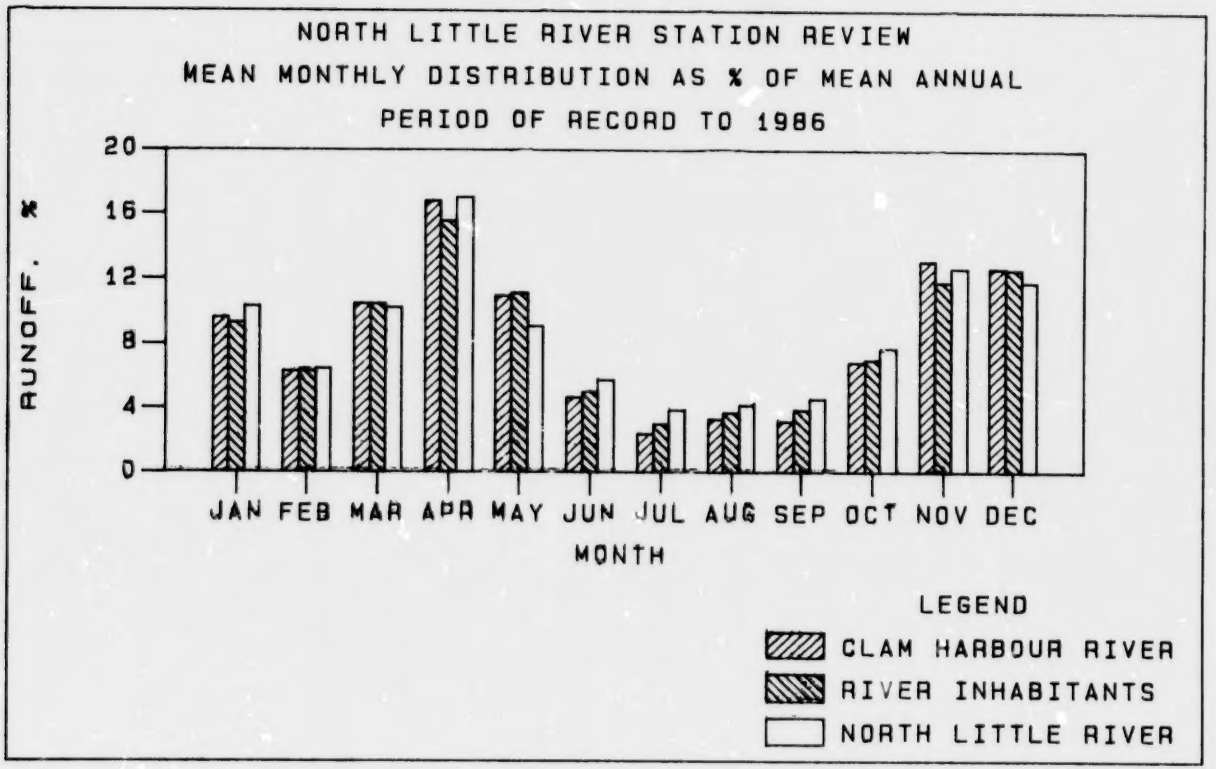

NORTH LITTLE RIVER STATION REVIEW
MEAN MONTHLY DISTRIBUTION AS % OF MEAN ANNUAL
PERIOD OF RECORD TO 1986
RUNOFF, %
20
16
12
8
4
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH
LEGEND
CLAM HARBOUR RIVER
RIVER INHABITANTS
NORTH LITTLE RIVER

FIGURE 3

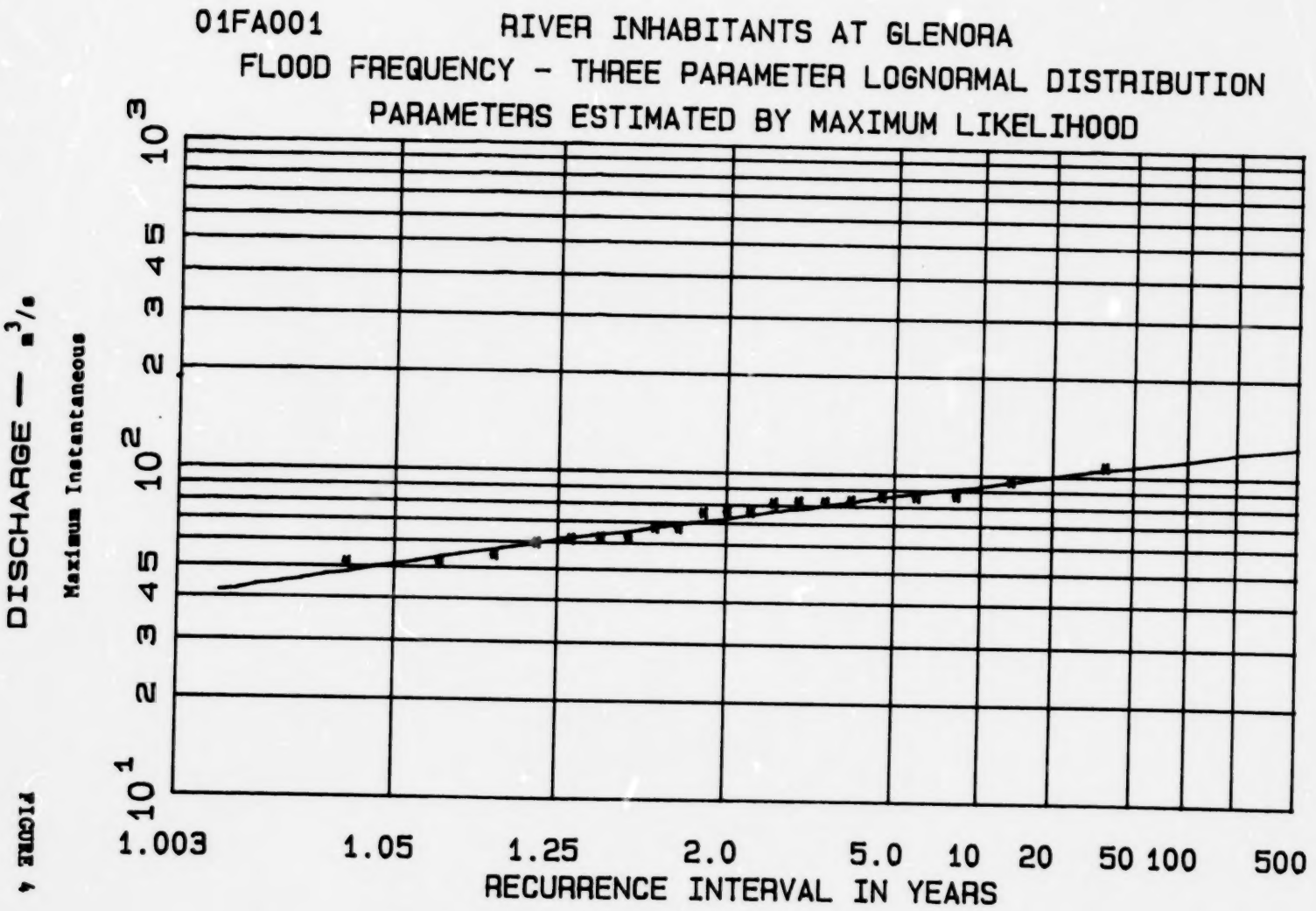

01FA001
RIVER INHABITANTS AT GLENORA
FLOOD FREQUENCY - THREE PARAMETER LOGNORMAL DISTRIBUTION
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD
DISCHARGE — m³/s
Maximum Instantaneous
10³
2 3 4 5
10²
2 3 4 5
10¹
2 3 4 5
1.003
1.05
1.25
2.0
5.0
10
20
50
100
500
RECURRENCE INTERVAL IN YEARS

FIGURE 4

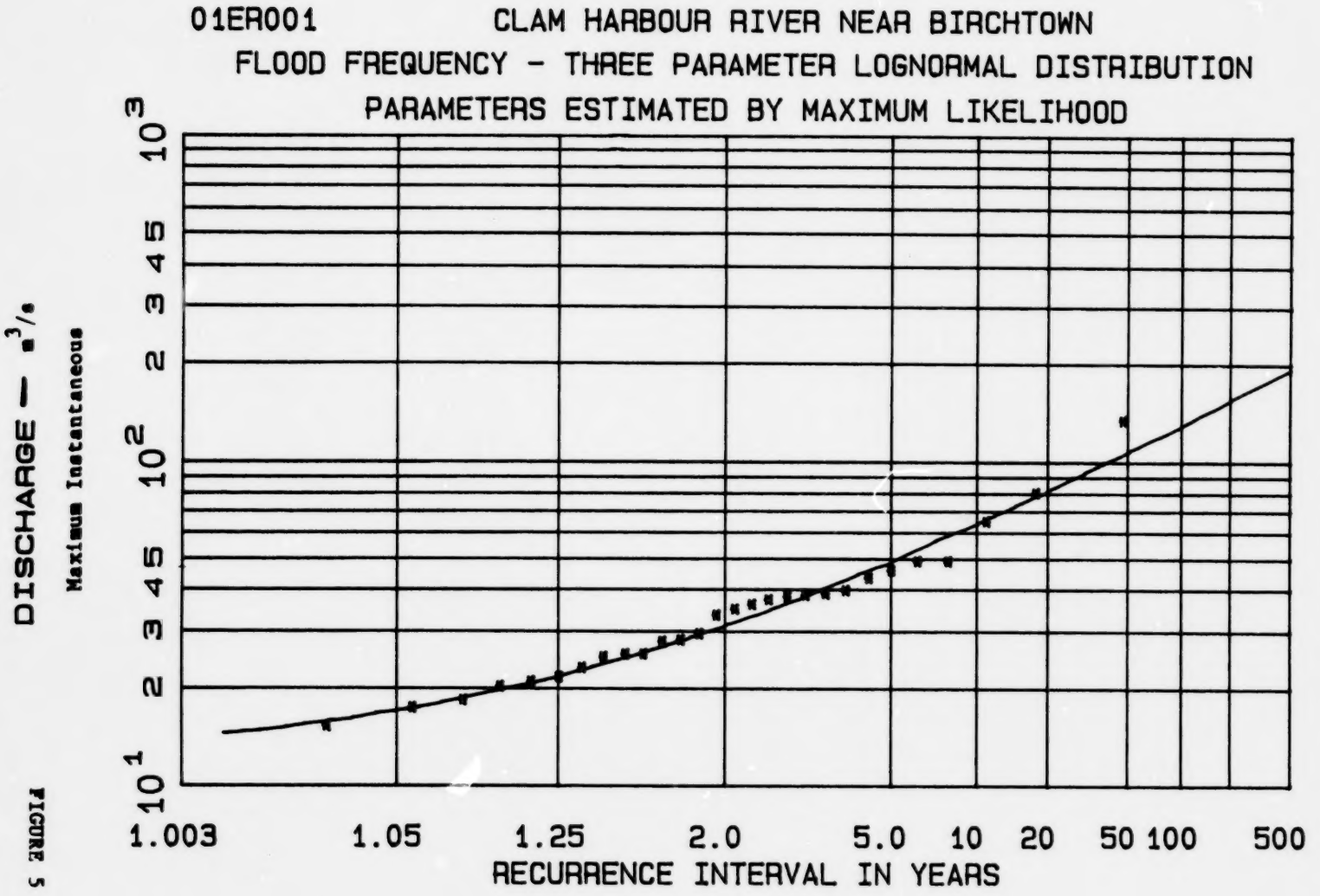

01ER001 CLAM HARBOUR RIVER NEAR BIRCHTOWN
FLOOD FREQUENCY - THREE PARAMETER LOGNORMAL DISTRIBUTION
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD
DISCHARGE — m3/s
Maximum Instantaneous
10^3
2 3 4 5
10^2
2 3 4 5
10^1
2 3 4 5
1.003
1.05
1.25
2.0
5.0
10
20
50
100
500
RECURRENCE INTERVAL IN YEARS

FIGURE 5

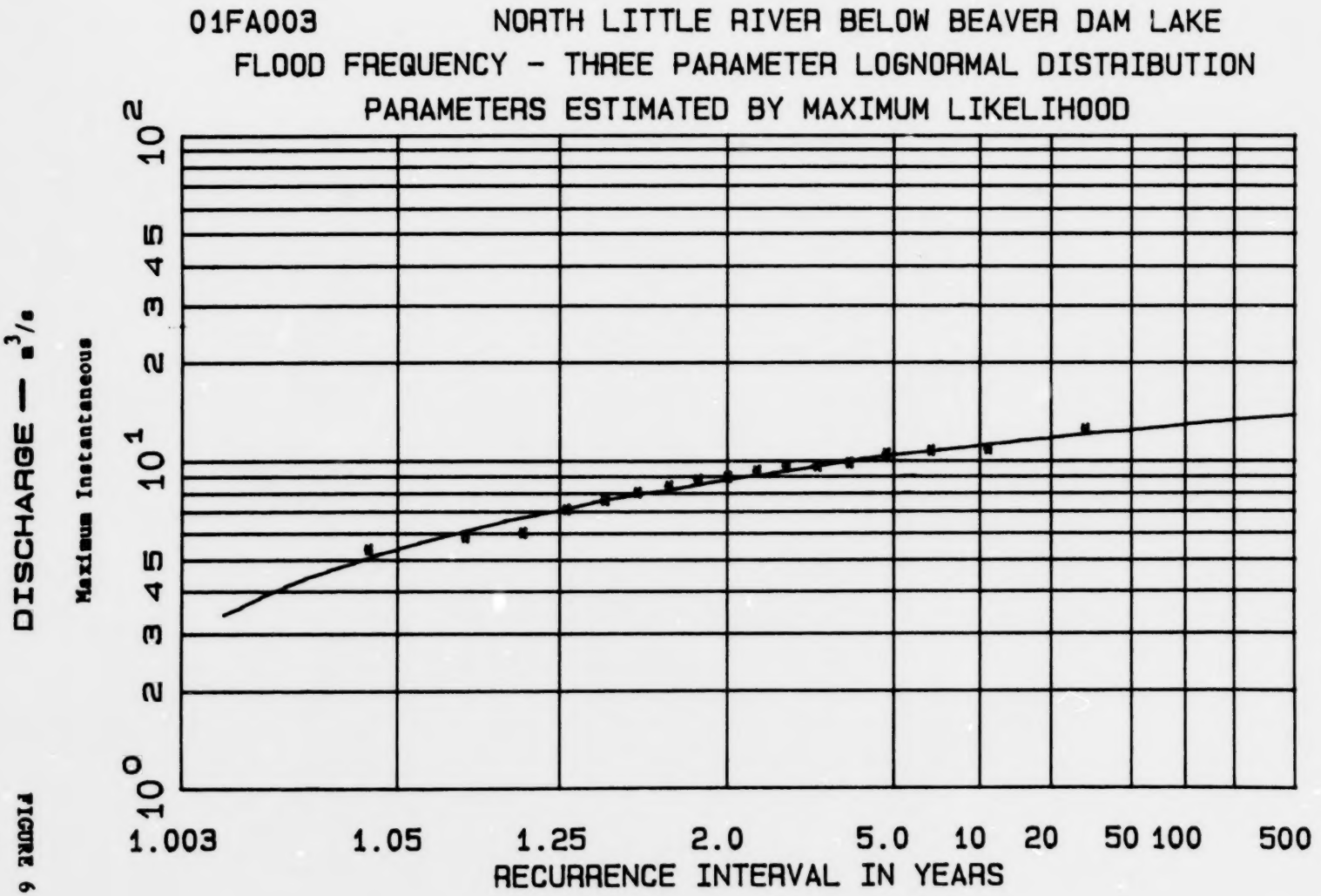

01FA003 NORTH LITTLE RIVER BELOW BEAVER DAM LAKE
FLOOD FREQUENCY - THREE PARAMETER LOGNORMAL DISTRIBUTION
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD
DISCHARGE — m³/s
Maximum Instantaneous
10⁰ 2 3 4 5 10¹ 2 3 4 5 10²
1.003 1.05 1.25 2.0 5.0 10 20 50 100 500
RECURRENCE INTERVAL IN YEARS

FIGURE 6

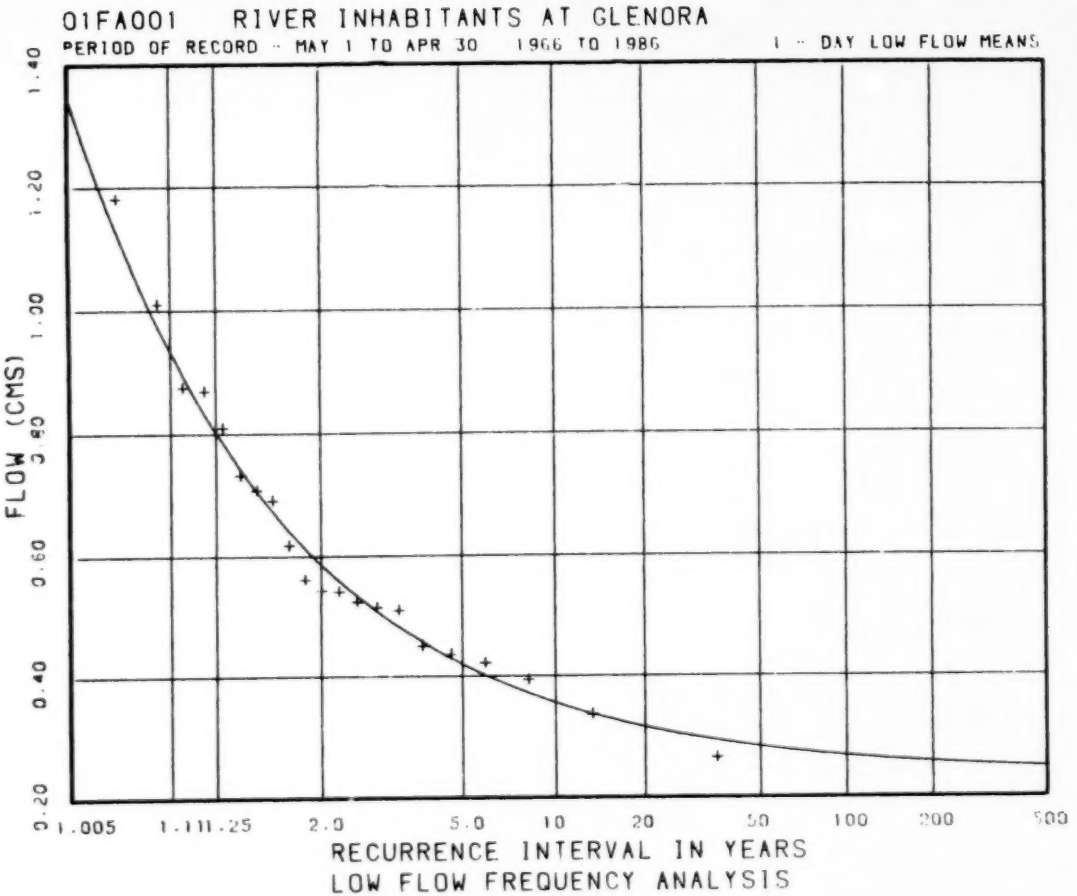

01FA001 RIVER INHABITANTS AT GLENORA
PERIOD OF RECORD - MAY 1 TO APR 30 1966 TO 1986
1 - DAY LOW FLOW MEANS
FLOW (CMS)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
1.005
1.111.25
2.0
5.0
10
20
50
100
200
500
RECURRENCE INTERVAL IN YEARS
LOW FLOW FREQUENCY ANALYSIS

FIGURE 7

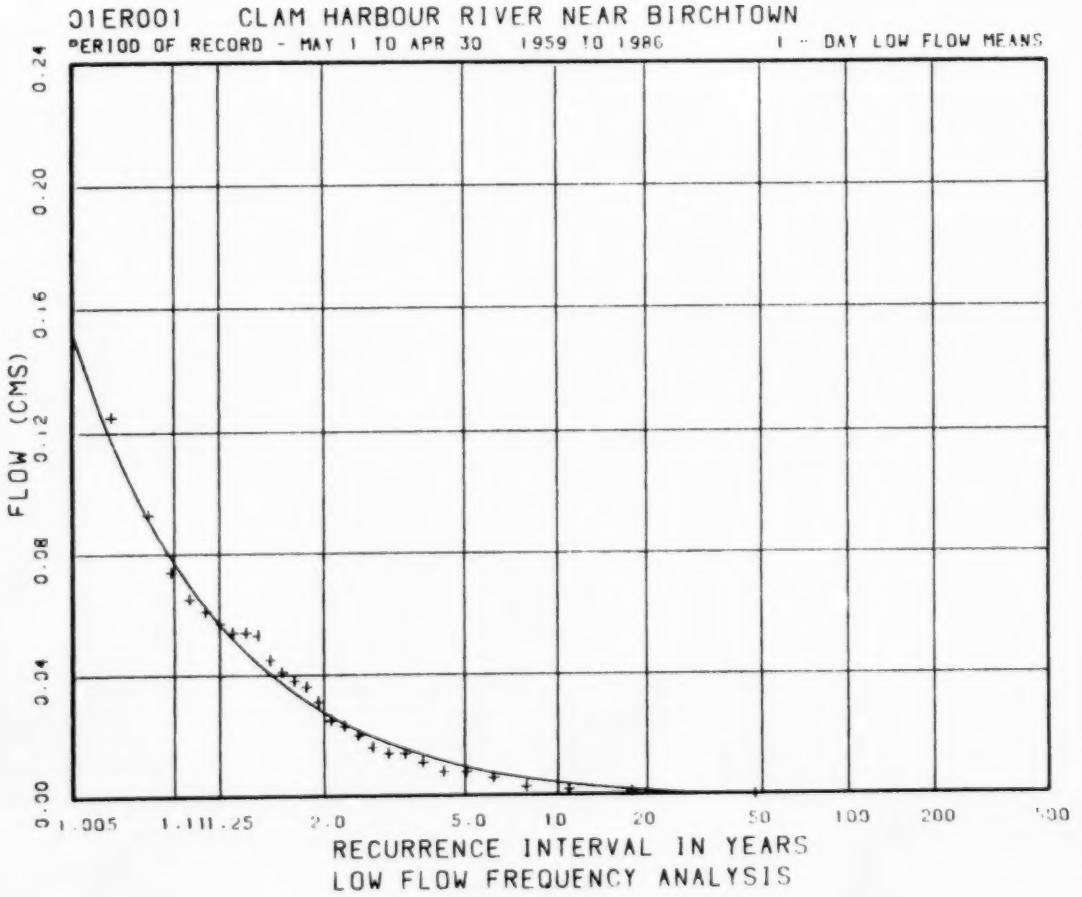

01ER001 CLAM HARBOUR RIVER NEAR BIRCHTOWN
PERIOD OF RECORD - MAY 1 TO APR 30 1959 TO 1986
1 - DAY LOW FLOW MEANS
FLOW (CMS)
0.00
0.04
0.08
0.12
0.16
0.20
0.24
1.005
1.11
1.25
2.0
5.0
10
20
50
100
200
500
RECURRENCE INTERVAL IN YEARS
LOW FLOW FREQUENCY ANALYSIS

FIGURE 8

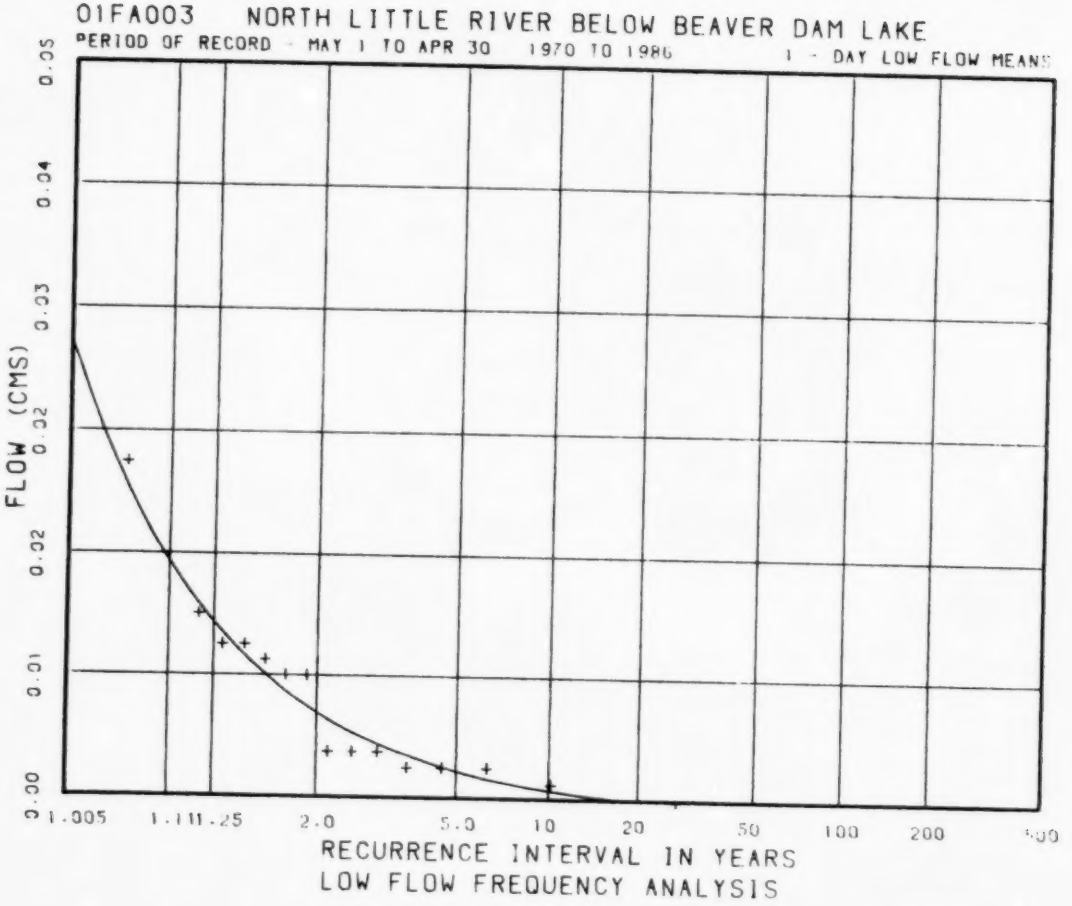

01FA003 NORTH LITTLE RIVER BELOW BEAVER DAM LAKE
PERIOD OF RECORD - MAY 1 TO APR 30 1970 TO 1986
1 - DAY LOW FLOW MEANS
FLOW (CMS)
0.00
0.01
0.02
0.03
0.04
0.05
1.005
1.111.25
2.0
5.0
10
20
50
100
200
500
RECURRENCE INTERVAL IN YEARS
LOW FLOW FREQUENCY ANALYSIS

FIGURE 6

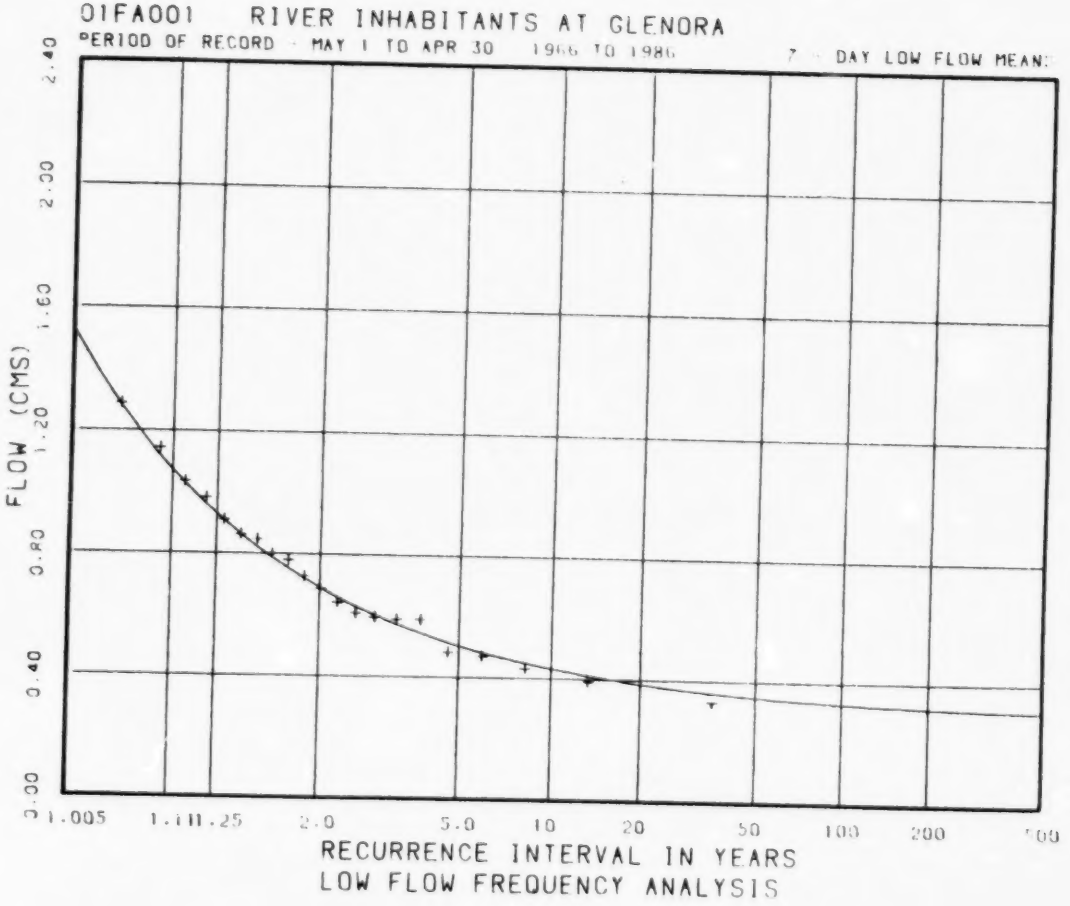

01FA001 RIVER INHABITANTS AT GLENORA
PERIOD OF RECORD - MAY 1 TO APR 30 1966 TO 1986
7 - DAY LOW FLOW MEANS
FLOW (CMS)
3.00
2.40
2.00
1.60
1.20
0.80
0.40
1.005
1.11
1.25
2.0
5.0
10
20
50
100
200
RECURRENCE INTERVAL IN YEARS
LOW FLOW FREQUENCY ANALYSIS

FIGURE 10

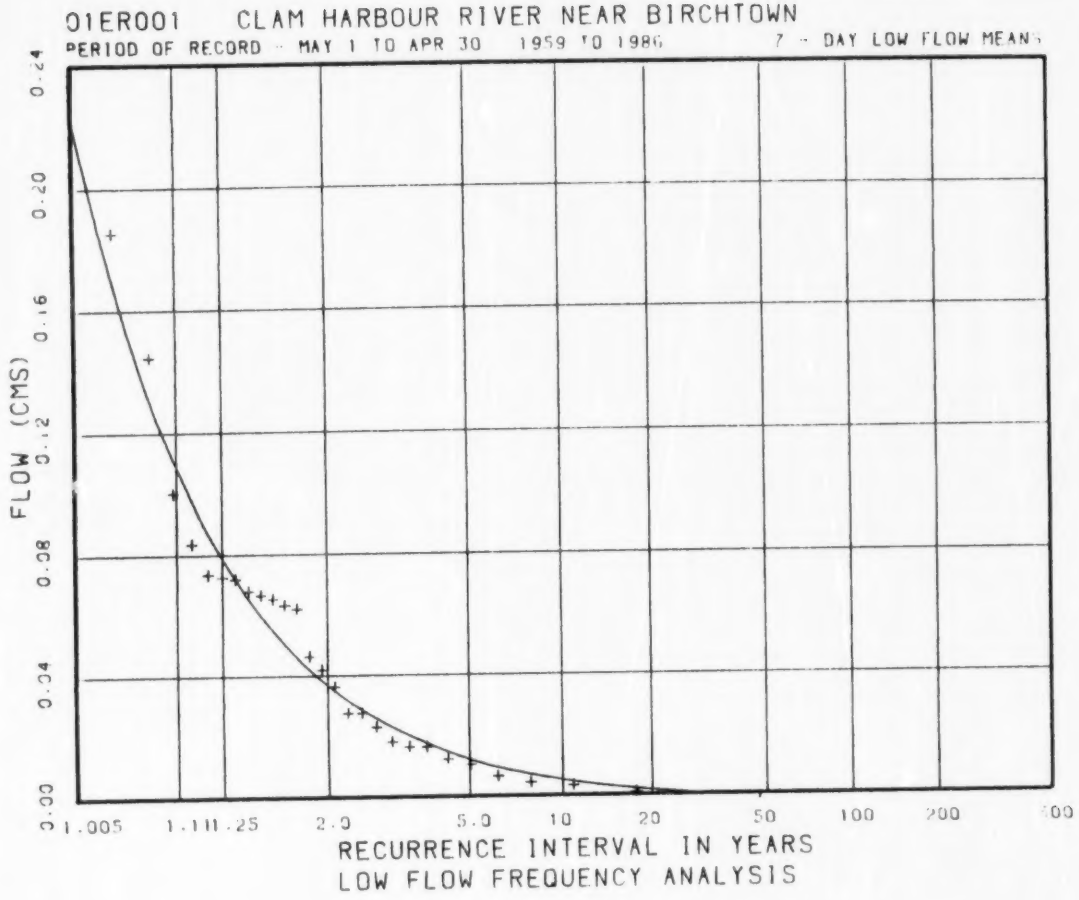

01ER001 CLAM HARBOUR RIVER NEAR BIRCHTOWN
PERIOD OF RECORD - MAY 1 TO APR 30 1959 TO 1986
7 - DAY LOW FLOW MEANS
FLOW (CMS)
0.00
0.04
0.08
0.12
0.16
0.20
0.24
1.005
1.11
1.25
2.0
5.0
10
20
50
100
200
500
RECURRENCE INTERVAL IN YEARS
LOW FLOW FREQUENCY ANALYSIS

FIGURE 11

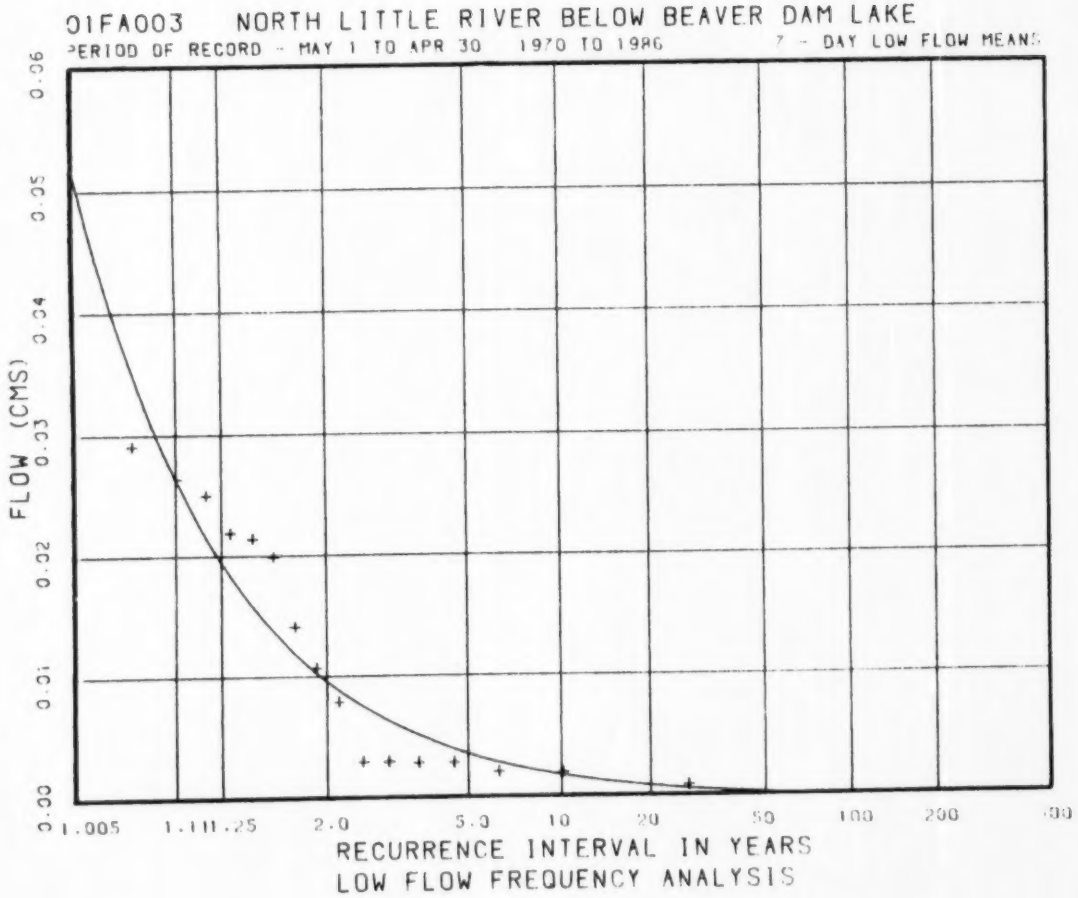
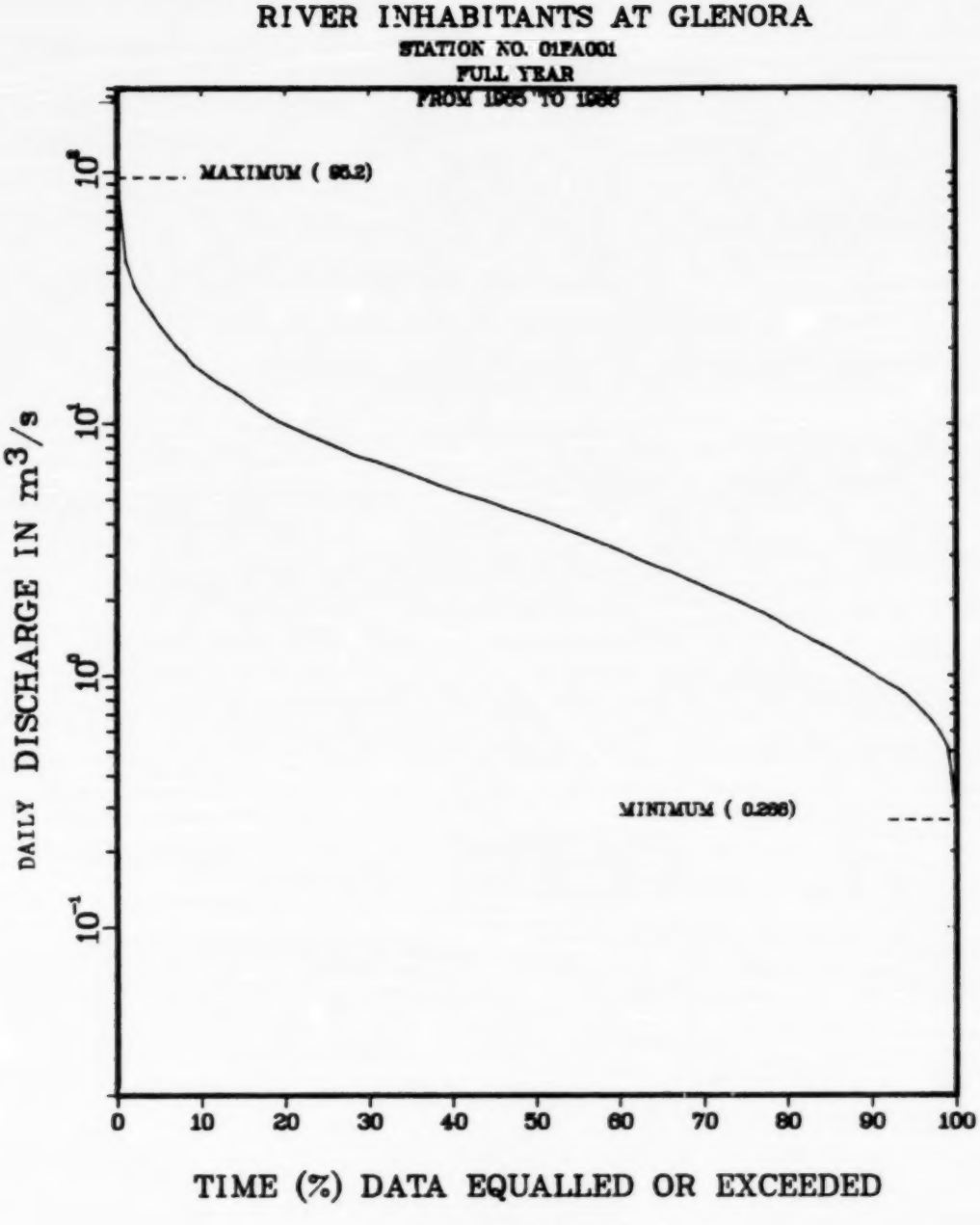
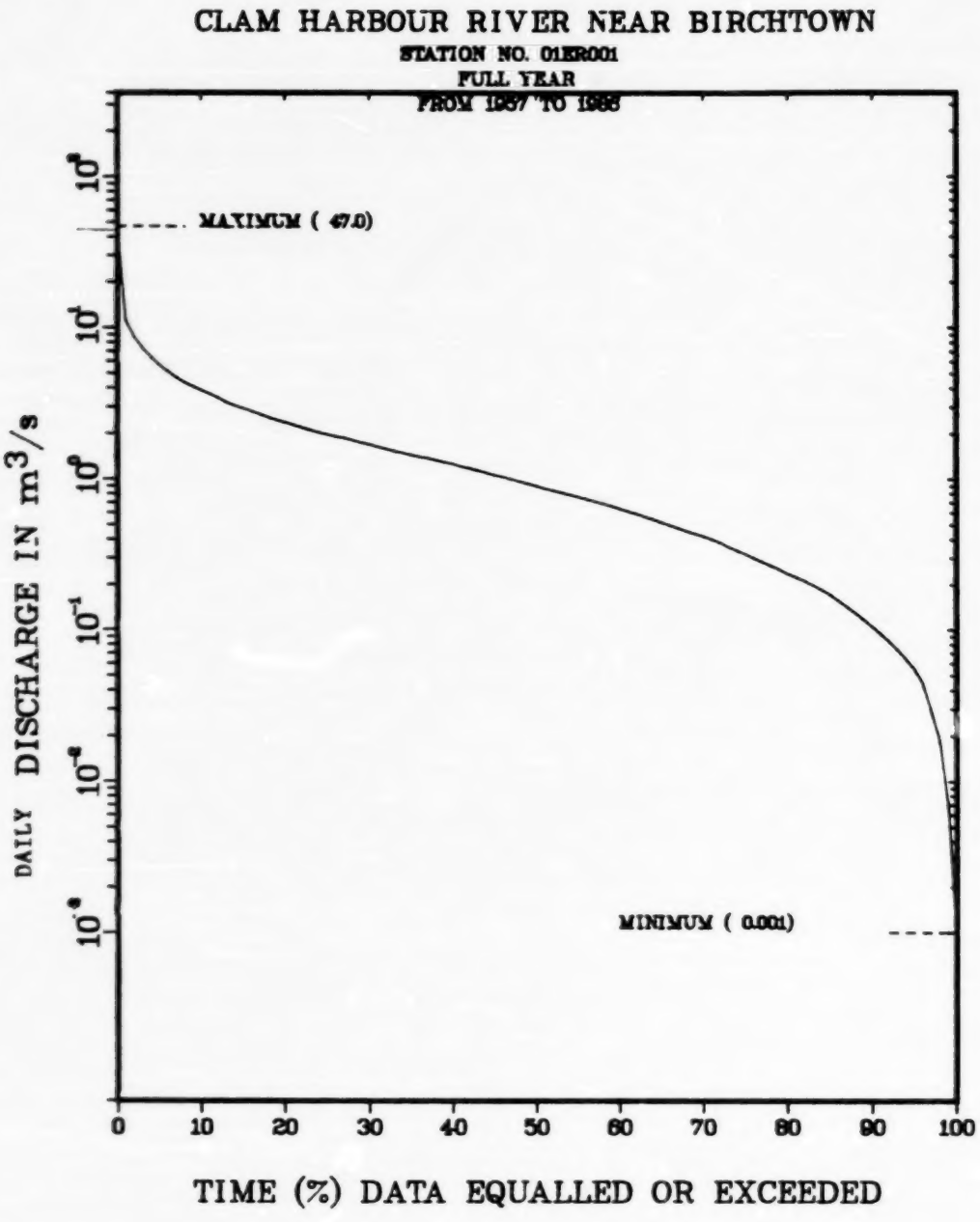

01FA003 NORTH LITTLE RIVER BELOW BEAVER DAM LAKE
PERIOD OF RECORD - MAY 1 TO APR 30 1970 TO 1986
7 - DAY LOW FLOW MEANS
FLOW (CMS)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
1.005
1.11
1.25
2.0
5.0
10
20
50
100
200
RECURRENCE INTERVAL IN YEARS
LOW FLOW FREQUENCY ANALYSIS

FIGURE 12



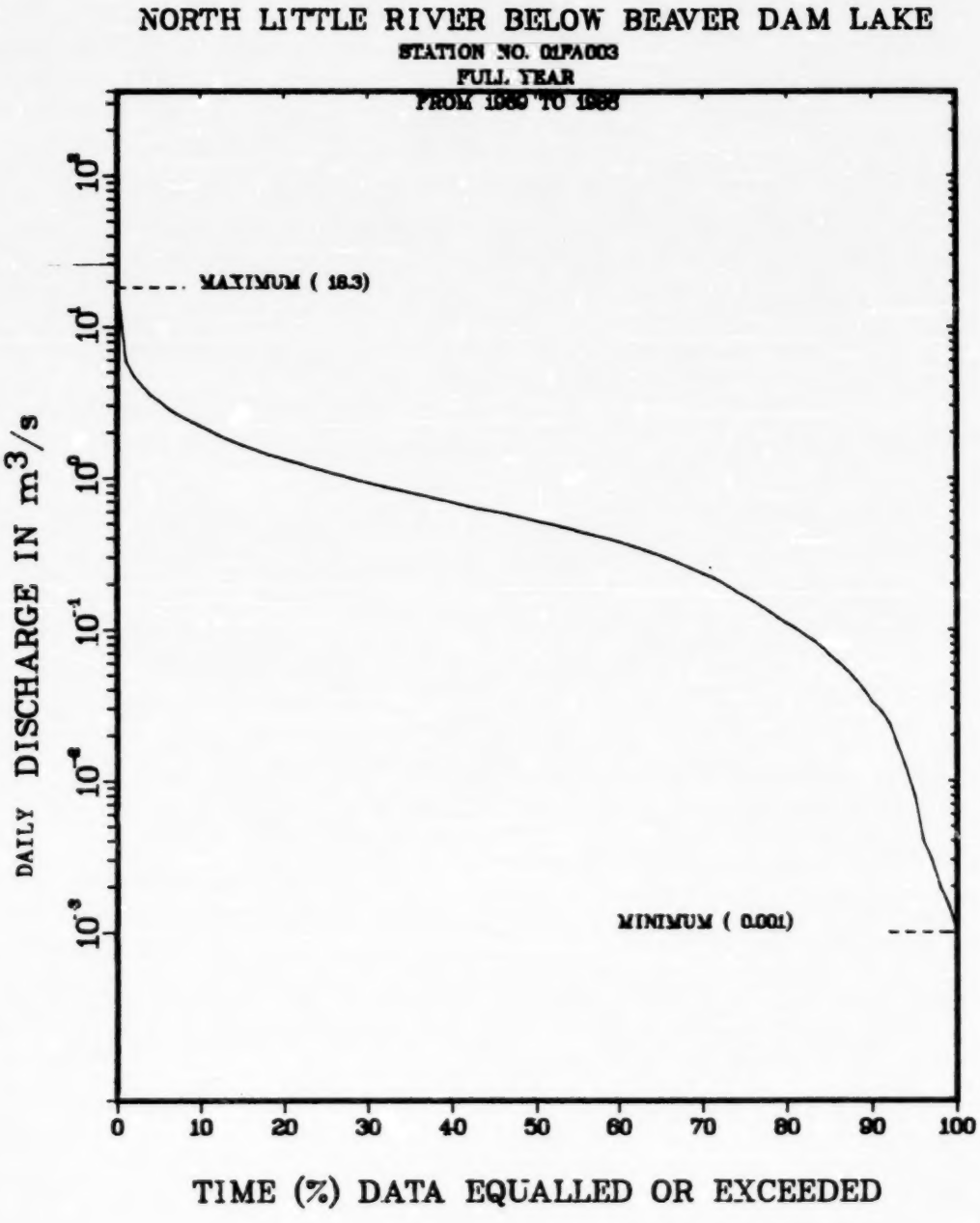
FLOW DURATION CURVE

FIGURE 13



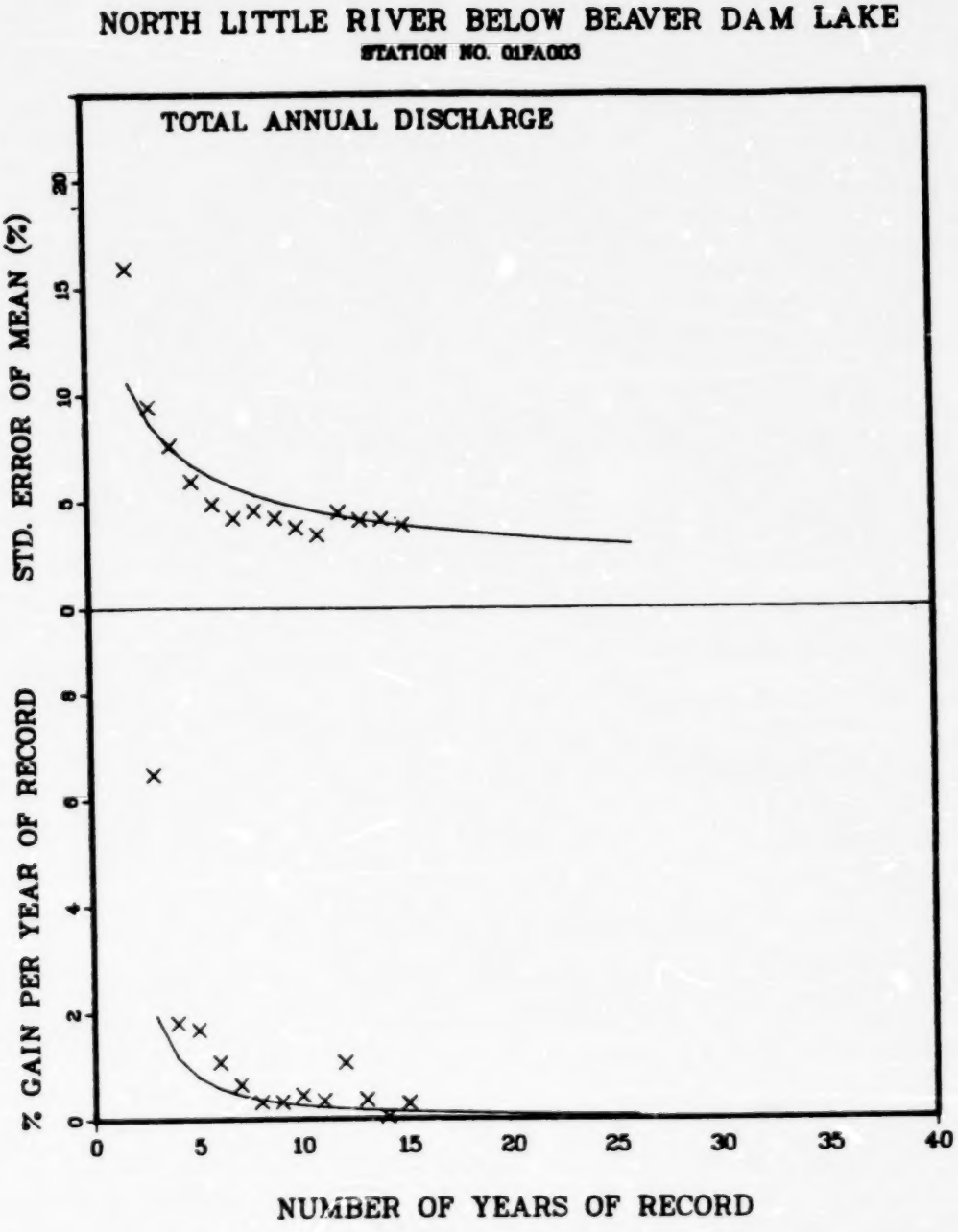
FLOW DURATION CURVE

FIGURE 14


NORTH LITTLE RIVER BELOW BEAVER DAM LAKE
STATION NO. 01FA003
FULL YEAR
FROM 1965 TO 1968
MAXIMUM (18.3)
MINIMUM (0.001)
DAILY DISCHARGE IN m3/s
TIME (%) DATA EQUALLED OR EXCEEDED

FLOW DURATION CURVE

FIGURE 15


NORTH LITTLE RIVER BELOW BEAVER DAM LAKE
STATION NO. 01FA003
TOTAL ANNUAL DISCHARGE
STD. ERROR OF MEAN (%)
% GAIN PER YEAR OF RECORD
NUMBER OF YEARS OF RECORD

RELATION BETWEEN THE STANDARD ERROR OF THE MEAN ANNUAL TOTAL DISCHARGE AND RECORD LENGTH. THE PERCENTAGE GAIN IN THE STANDARD ERROR OF THE MEAN FOR EACH ADDITIONAL YEAR OF RECORD IS SHOWN IN THE BOTTOM HALF OF THE FIGURE.

FIGURE 16